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Description

[0001] The present invention relates to a method, as well as a system for determination of relative position and/or orientation of a number of points or geometrical objects as planes, lines, holes, cylinders or spheres, or combined objects as robot arms or other industrial production equipment, based on the use of one or multiple cameras based on electro optical sensors in combination to fixed mounted light sources, projected light spots, illuminated reflectors or probing tools having light sources or reflectors attached to it.

[0002] The present patent application describes a further development of the inventions described by the inventors in Norwegian patents 165 046,164 946 and 169 799, as well as WO 93/07443.

[0003] Norwegian patent 165 046 describes a system based on two high resolution electro optical cameras which are calibrated for angle measurements, methods for such calibration, a system for geometry measurements based on the cameras, as well as application of this system.

[0004] Norwegian patent 164 946 describes systems for measurements of points on a surface, by projecting a pattern of light spots onto the surface, and by determining the coordinates for these light spots by the use of electro optical sensors.

[0005] Norwegian patent 169 799 describes tools for marking points on a surface, to be measured by the use of electro optical cameras.

[0006] WO 93/07443 describes a system for measurement of spatial coordinates by the use of a single electro optical camera as well as tools having light source or reflecting points attached to it.

[0007] The system that is described in Norwegian patent 165 046 has limitations related to the fact that each individual point is registered simultaneously by two cameras. That leads to requirements for simultaneous free visibility in directions to both cameras. Furthermore the system is based on determination of the position of the cameras by a separate procedure before coordinate measurements can be started. The system accuracy is basically determined by the resolution of the sensor. This means that the accuracy is limited in large volumes.

[0008] The system described in WO 93/07443 functions essentially as a theodolite, in that spatial directions are determined with high accuracy. In addition the distance to the measurement tool is determined with moderate accuracy. As a stand alone system it gives limited accuracy in distance determination, which means that the number of possible applications is limited.

[0009] If the system described in the present patent application is used in combination with a system based on two angle sensors as described in Norwegian Patent No. 165046, it will be an advantage first to position a number of auxiliary reference points and to measure their accurate position relative to a relevant coordinate system by the use of multiple angle sensor locations.

[0010] Then, by using one or two angle sensors to measure only a small part of the overall object, these auxiliary reference points can be used to relate all measurements to the correct coordinate system.

[0011] The use of a probing tool having light sources in known from WO-A-91/16598.

[0012] The present patent application describes a further development of method and means for coordinate measurement that gives full flexibility with respect to:

- the number of cameras,
- whether the cameras are calibrated for direction measurements or not,
- the methods used for marking the measurement points,
- where, and in how many positions the cameras are located during the measurement process.
- which methods that are used to relate the measurements to a selected coordinate system.

[0013] By the use of this further development full flexibility to optimize the system and the method with respect to the measurement task in question, and to questions like accuracy requirements and exterior limitations like visuality limitations is achieved.

[0014] Regarding applications, the system is competing to existing technology like theodolites and conventional photogrammetry, as well as mechanical coordinate measurement machines.

[0015] Coordinate measuring machines have strongly limited functionality, as they are not portable and have a limited measurement volume. Large machines are very expensive, have low accuracy, and require dedicated rooms due to the need for stability and temperature control.

[0016] Theodolites have significant limitations related to operator dependencies (in conventional instruments an operator is aiming towards the measurement point through the monocular of the theodolite), time consuming measurements, and to strong requirement for free visibility between the measurement point and the instrument. In addition theodolites must be levelled accurately.

[0017] Conventional photogrammetry is limited to the use of film based cameras. The measurement points are marked by attaching reflecting measurement elements called targets, to the object. It is not possible to measure geometrical objects like holes, planes, spheres, lines, etc. without marking these by the use of targets.

[0018] Calculation of spatial coordinates based on theodolite measurements or conventional photogrammetry is done by iterative methods. Both measurement methods are two dimensional, i.e. they give the direction towards the measurement points only. Estimated spatial coordinates for a number of the measurement points are needed as initial values for the iterative calculations. The system described in WO 93/07443 gives spatial coordinates, which gives sufficiently accurate initial values

for the similar calculations related to the present method and system.

Figure 1 illustrates camera and imaging of a light spot on the sensor of the camera.

Figure 2 illustrates the principle of coordinate determination from the imaging of a common point in two or more cameras.

Figure 3 illustrates the configuration of a complete measurement system.

[0019] Norwegian patent no. 165 046 describes a fully automatic and accurately calibrated angle sensor based on a CCD camera. Such a camera 1, as shown in figure 1. comprises essentially a camera house 2, a lens unit 3, and a two dimensional sensor matrix 4. The lens unit is an objective with standard, spherical optics. The angle sensor is developed to measure the direction towards points being active light sources or points illuminated by active light sources. This gives a secure identification of the measurement points, and hence enables a fully automatic use, as well as gives a very high signal to noise ratio. High accuracy is furthermore ensured by the use of accurate procedure for calibration of the angle sensor. This is described in Norwegian patent 165 046.

[0020] The measurement principle is illustrated in figure 2. The coordinates for a number of points 5 shall be determined relative to a spatial coordinate system X, Y, Z. This is done by locating two or more cameras 4 in arbitrary and initially unknown positions and orientations relative to the same coordinate system. The spatial direction to a point 5 is determined by registering its projection 6 through the projection center 7 of the lens unit as shown in figure 1 B. The projection is registered as the image coordinates x, y of the point image relative to a camera fixed coordinate system as illustrated in figure 2. The calculation of the unknown spatial coordinates is based on setting up the equations for the projections for a number of cameras. This calculation may also include determination of the position and orientation of the cameras, as well as including parameters for correction of possible lens distortions. This means that even non-calibrated cameras may be applied. Each additional point that is introduced in the calculation gives three additional unknown coordinates X, Y, Z to be determined. at the same time as 2 x n new observations are included in the calculation (n is the number of camera locations). The calculation requires the magnitude of at least one distance between two points to be known to give correct scale information to the system of equations.

[0021] The method of calculation is based on minimizing errors (least squares method), such that redundant information is used. The necessary mathematical foundation is found in H.M. Kamara (Ed.): Non-topographic photogrammetry. Second Edition, 1987, page 37-55.

[0022] Generally, if the number of unknown parameters is increased, a similarly increased number of observations as additional points or additional cameras/camera locations is required.

[0023] Figure 3 illustrates a system for spatial geometry measurements based on one or multiple cameras 1, 8, a system control unit 9 consisting of data processor 10, camera control unit 11 and light source control unit 12. The system can be attached to different light sources for marking points:

- Reference bar 14 comprising a number of light emitting diodes at known mutual separation distances.
- Light pen 15, which is a probing tool described in Swedish patent no. 456 454, possibly having exchangeable tools as described in Norwegian patent no. 169 799.
- Light emitting diodes and/or lasers 16. Light emitting diodes are attached permanently in the measurement field to be imaged from multiple camera locations. Lasers are used to project fixed light spots onto the measurement object. Light emitting diodes / lasers are connected to the system via a connector unit 17.
- Reflecting points 18 which are illuminated by a lamp 19.

[0024] Driving and control of the light sources is done by the control unit 12 to ensure optimum signal to noise ratio, and to synchronize to the cameras via the camera control unit 11.

[0025] The systems data processor 10 is doing the analysis of measurement data from the cameras. The data processing mainly consist of:

- control of imaging time and exposure time to optimize the signal to noise ratio,
- identification of the individual light sources, i.e. which point in the image that corresponds to which light source,
- calculation of the spatial direction for each individual light source from the image information,
- calculation of spatial coordinates for the probing tool (light pen).

[0026] The user is communicating with the system via an operator terminal 13.

[0027] In addition to the observations from the cameras, the method of calculation requires one or more known distances to give the correct scale to the calculated spatial coordinates. This can be achieved by the use of the specially designed reference bar 14, or by measuring points in a known separation distance. The

length of the reference bar or the known distances may be typed in by the operator at the terminal 13.

[0028] The present invention proposes to apply one or more cameras in combination with one or more types of light sources or illuminated reflecting points to achieve high flexibility to solve various measurement problems with respect to

- the dimension of the measurement volume,
- the accessibility to the measurement volume,
- definition of coordinate systems,
- accuracy requirements,
- available time for measurements,
- frequency of repeated controls,
- combination of different types of cameras and instruments for direction measurements.

[0029] The invention solves these problems by a method as defined in claim 1 and by a system as defined in claim 14. Advantageous embodiments of this method and this system are defined in claims 2 to 13 and 15 to 26.

Figure 4	illustrates the further developed principle for the use of the probing tool "light pen".
Figure 5	illustrates how to establish and measure a network of help reference points.
Figure 6	illustrates measurement of a number of geometrical objects based on a number of help reference points.
Figure 7	illustrates an application based on a transportable reference structure / pallet.
Figure 8	illustrates a permanent measurement station based on a reference structure.

[0030] Figures 9 and 10 show examples of use of the method of the invention.

[0031] The computation method that is described above and that is related to figure 2, is based on the possibility of seeing the same point from a number of different camera positions. Generally light sources, generated by direct emission from a light emitting diode or indirect as a reflection from a reflecting material or a projected laser spot, can be seen from "one side" only. Optimum accuracy in the computation method is achieved if the directions of observations are uniformly distributed. This is achieved by the light pen.

[0032] The light pen 15 that by itself is known from WO 93/07443 is in this context used differently as only the direction to the touch point of the light pen is to be registered and to be used for coordinate determination. The principle for use of the light pen is shown in figure 4. The light pen is registered on the sensor as a number of image spots 6 corresponding to the light emitting diodes 5. The direction to the light pen should be related to a touch point 20. This corresponds to an image point 21 on the sensor. As the sensor is registering the image of light sources only, this will be a virtual image spot. The image coordinates of the image point 21 will be calculated from the registered image coordinates for each light source, as well the knowledge of the mutual position of the light sources 5 and the touch point 20 in a probe fixed, local coordinate system. The calculation methods are further described in WO 93/07443.

[0033] If the touch point of the light pen is kept in a fixed position, the light pen itself can be rotated to be aimed towards the different camera positions in question. Hence, this gives the necessary geometry for the computation method. The fact that the light pen has a number of light emitting diodes makes the accuracy in determining the projection of the touch point better than for a single light emitting diode.

[0034] Figure 5 illustrates the use of the system to determine the geometry of an object 22. The positions of a number of points or geometrical objects (holes, planes, cylinders etc.), in the figure marked with capital letters A - C, are to be determined with high accuracy relative to the resolution of the cameras, the size of the measurement volume, its accessibility etc. The method consist of distributing a number of help reference points (in the figure marked with tower case letters a - u) all over the measurement volume. These can be light emitting diodes, projected laser spots, reflecting points or marked points that can be touched with the light pen. By registering the projection of these points on the camera sensors for a number of different camera locations, this will give data for calculation of the mutual position of all points, as described above with reference to figure 2. The computation is flexible with respect to:

- the number of cameras or camera locations,
- the number of points observed in each camera location (a minimum number is required, depending on the number of camera parameters to be determined),
- the number of observations for each individual point.

[0035] In general the accuracy is improved if the number of observations (points) in each camera location is increased, and if the number of camera locations is increased. A single camera or multiple cameras can be used. If the cameras are not calibrated with respect to the imaging properties of the lens, it is advantageous to

have as few different cameras as possible.

[0036] If, on the other hand, it is necessary to do the measurements fast, the data acquisition can be made efficient by using multiple, calibrated cameras in fixed locations, and by using as few locations and points as possible.

[0037] The relation to an object fixed coordinate system requires some points that are defining the coordinate system by their coordinate values being known along one or more of the coordinate axes, or by doing a best fit of defined values to the calculated positions.

[0038] Figure 6 illustrates how to start from a number of points in known positions relative to an object fixed coordinate system and then to measure additional points within or outside the object by the use of two or more cameras. If a network of points is available, as shown by letters a - u, it is possible by the use of only two cameras 1,8 to locate these such that they are seeing not more than the area of interest. At first the position and orientation of the cameras relative to the object fixed coordinate system are determined by registering the projection of the known points a, b, c. The coordinates of these points relative to the coordinate system X, Y are known from a measurement as described above with reference to figure 5. This method gives a quick measurement, having a high accuracy.

[0039] An application of this method is illustrated in figure 7 a, b, which as an example may describe a welding station in a production line for car bodies as shown in figure 8 a,b. The under part of the car body is based on a fixture 24, while the side parts of the car body are held in place by fixtures 23. The mount of the car body parts to the fixtures are made by the use of steering pins and-clamping mechanisms 27. These are controlling the location of each different component during the welding process, and have to be in the correct location to ensure correct shape of the assembled car body. Control of each individual object is efficiently made by the method described above (figure 6) by having a number of fixed help reference points distributed all over the whole station. An alternate solution is shown in figure 7 a, where the help reference points a - u are attached to a portable jig 24 that can be moved into the station when a measurement is to be made. The location of this jig is in such a case controlled by the main references 25, 26 of the station (e.g. steering pins) that are holding the jig in a fixed position. The positions and orientations of the two cameras 1,8 relative to the object fixed coordinate system are first determined by registering the directions towards the known points a - u. The advantages of this method is that each individual station in the whole production line is based on a single jig with a fixed and well known geometry, such that a unique, accurate geometry is ensured all along the production line. Hence, the error propagation through the production line is kept to a minimum. Furthermore, it will not be necessary to have an extensive network of points in each individual station.

[0040] Figure 9 shows another application of the same principle. In this case the reference points are fixedly permanently mounted in a structure 28, while the object 29 to be measured is transported into this structure. As an example this method can be applied in a production line based on transportable jigs for transport of components into the welding stations. Control of these jigs on a regular basis can be done in fixed measurement stations.

[0041] Figure 10 shows an example of this, where the object 30 is an aircraft that is brought to a measurement station where the reference points are placed on the floor or in a surrounding fixture.

[0042] The system known per se shown in figure 3 must, to cover the methods described above, be extended with respect to the data processor 10, the camera control unit 11 and the light source control unit 12. In this context it is required that these units shall be able to take into account:

- different types and number of cameras,
- different types and number of light sources and help tools,
- different calculation methods depending on the configuration of cameras and light sources that are used and which type of known information (defined coordinate values in a local coordinate system or given distances between points) that should be included in the calculation.

[0043] Some examples of applications are described above. These shall be considered as examples only, as a large number of different other objects may be measured by the same methods and the same system. This includes large as well as small objects within automotive, aerospace or other mechanical industry.

Claims

1. A method for determining the position and/or orientation of a number of points or objects relative to each other, the method comprising the steps of:

   (A) providing at least two cameras;
   (B) establishing a network of help reference points;
   (C) determining the spatial positions of some points in the network relative to each other using at least one of the cameras positioned in multiple arbitrary locations, said at least one camera determining projections of the positions of said some network points;
   (D) positioning some of the cameras, so that they can view at least three help reference points

(E) determining the positions and orientations of the some of the cameras using the spatial positions of network points determined in step (C); and
(F) determining the position and/or orientation of some of the points or objects relative to each other, based on the determined positions and orientations of some of the cameras, whereby the position and/or orientation of at least one of the points or objects is determined by:

(i) holding a probing tool in contact with the point or at least one point on the object, and
(ii) obtaining measurement data from the probing tool using at least two of the cameras whose positions were determined in step (E).

2. The method according to claim 1, wherein the network of help reference points includes at least two points having a known mutual separation distance being used to determine a correct length scale.

3. The method according to claim 2, wherein the at least two points are positioned on a reference bar.

4. The method according to one of claims 1 to 3, wherein the help reference points are chosen from light sources, projected light spots and illuminated reflectors or are points that can be touched by a probing tool having light sources or reflectors attached to it.

5. The method according to claim 4, wherein the light sources are light-emitting diodes.

6. The method according to claim 4 or 5, wherein at least some of the help reference points are light sources.

7. The method according to one of claims 4 to 6, wherein the position of at least one of the help reference points is determined using the probing tool.

8. The method according to one of claims 1 to 7, wherein the lens distortions of the cameras are determined based on the spatial positions of the help reference points.

9. The method according to one of claims 1 to 8, wherein the network of help reference points is established within a certain volume and wherein the objects are brought within this volume prior to performing step (F) of claim 1.

10. The method according to one of claims 1 to 9, wherein the objects are locating and/or holding devices in a station of a production line.

11. The method according to one of claims 1 to 10, wherein the network of help reference points is established on a movable device and that the movable device is moved into a station in a production line prior to performing steps (E) and (F) of claim 1.

12. The method according to claim 11, wherein the movable device is moved into each of a plurality of stations in a production line prior to performing steps (D), (E) and (F) of claim 1 in each of the stations.

13. The method according to one of claims 1 to 12, wherein the objects comprise planes, lines, holes, cylinders, spheres and/or combined objects as robot arms or other industrial production equipment.

14. System for determining the position and/or orientation of a number of points or objects relative to each other, comprising:

(A) at least two cameras;
(B) means for establishing a network of help reference points;
(C) means for determining the spatial positions of some points in the network relative to each other using at least one of the cameras positioned in multiple arbitrary locations, said at least one camera determining projections of the positions of said some network points;
(D) means positioning some of the cameras, so that they can view at least three help reference points
(E) means for determining the positions and orientations of the some of the cameras using the spatial positions of network points determined in step (C); and
(F) means determining the position and/or orientation of some of the points or objects relative to each other, based on the determined positions and orientations of some of the cameras, whereby the position and/or orientation of at least one of the points or objects is determined by:

(i) a probing tool in contact with the point or at least one point on the object, and
(ii) means obtaining measurement data from the probing tool using at least two of the cameras.

15. The system according to claim 14, wherein the network of help reference points includes at least two points having a known mutual separation distance being used to determine a correct length scale.

16. The system according to claim 14 or 15, wherein the at least two points are positioned on a reference

bar.

17. The system according to one of claims 14 to 16, wherein the help reference points are chosen from light sources, projected light spots and illuminated reflectors or are points that can be touched by a probing tool having light sources or reflectors attached to it.

18. The system according to claim 17, wherein the light sources are light-emitting diodes.

19. The system according to claim 17 or 18, wherein at least some of the help reference points are light sources.

20. The system according to one of claims 17 to 19, wherein the position of at least one of the help reference points is determined using the probing tool.

21. The system according to one of claims 14 to 20, wherein the lens distortions of the cameras are determined based on the spatial positions of the help reference points.

22. The system according to one of claims 14 to 21, wherein the network of help reference points is established within a certain volume and wherein the objects are brought within this volume.

23. The system according to one of claims 14 to 22, wherein the objects are locating and/or holding devices in a station of a production line.

24. The system according to one of claims 14 to 23, wherein the network of help reference points is established on a movable device and that the movable device is moved into a station in a production line.

25. The method according to claim 24, wherein the movable device is moved into each of a plurality of stations in a production line.

26. The method according to one of claims 14 to 25, wherein the objects comprise planes, lines, holes, cylinders, spheres and/or combined objects as robot arms or other industrial production equipment.

Patentansprüche

1. Ein Verfahren zum Bestimmen der Position und/oder der Orientierung einer Anzahl von Punkten oder Gegenständen relativ zueinander, wobei das Verfahren folgende Schritte aufweist:

    (A) Vorsehen von mindestens zwei Kameras;
    (B) Erstellen eines Netzwerks von Hilfsreferenzpunkten;
    (C) Bestimmen der räumlichen Positionen einiger Punkte in dem Netzwerk relativ zueinander unter Verwendung von mindestens einer der Kameras, positioniert an vielfachen willkürlichen Orten, wobei mindestens eine Kamera Projektionen der Positionen der einigen Netzwerkpunkte bestimmt;
    (D) Positionieren einiger der Kameras, so dass sie mindestens drei Hilfsreferenzpunkte sehen können;
    (E) Bestimmen der Positionen und Orientierungen der einigen der Kameras unter Verwendung der räumlichen Positionen der Netzwerkpunkte, bestimmt in Schritt (C); und
    (F) Bestimmen der Position und/oder der Orientierung einiger der Punkte oder Gegenstände relativ zueinander, auf der Basis der bestimmten Positionen und Orientierungen einiger der Kameras, wobei die Position und/oder die Orientierung von mindestens einem der Punkte oder Gegenstände bestimmt wird durch

        (i) Halten eines Messfühlerinstrumentes in Kontakt mit dem Punkt oder mindestens einem Punkt auf dem Gegenstand, und
        (ii) Erhalten von Messdaten von dem Messfühlerinstrument unter Verwendung von mindestens zwei der Kameras, deren Positionen in Schritt (E) bestimmt wurden.

2. Verfahren nach Anspruch 1, bei welchem das Netzwerk von Hilfsreferenzpunkten mindestens zwei Punkte mit einem bekannten gegenseitigen Trennabstand aufweist, der verwendet wird, um eine korrekte Längenskala zu bestimmen.

3. Verfahren nach Anspruch 2, bei welchem die mindestens zwei Punkte auf einem Bezugsstab positioniert sind.

4. Verfahren nach einem der Ansprüche 1 bis 3, bei welchem die Hilfsreferenzpunkte ausgewählt werden aus Lichtquellen, projizierten Lichtpunkten und beleuchteten Reflektoren oder Punkten, die von einem Messfühlerinstrument berührt werden können, auf welchem Lichtquellen oder Reflektoren angeordnet sind.

5. Verfahren nach Anspruch 4, bei welchem die Lichtquellen lichtemittierende Dioden sind.

6. Verfahren nach Anspruch 4 oder 5, bei welchem mindestens einige der Hilfsreferenzpunkte Lichtquellen sind.

7. Verfahren nach einem der Ansprüche 4 bis 6, bei welchem die Position von mindestens einem der

Hilfsreferenzpunkte unter Verwendung des Messfühlerinstrumentes bestimmt wird.

8. Verfahren nach einem der Ansprüche 1 bis 7, bei welchem die Linsenverzeichnungen der Kameras auf der Grundlage der räumlichen Positionen der Hilfsreferenzpunkte bestimmt werden.

9. Verfahren nach einem der Ansprüche 1 bis 8, bei welchem das Netzwerk der Hilfsreferenzpunkte innerhalb eines bestimmten Volumens erstellt wird und bei welchem die Gegenstände in dieses Volumen vor der Durchführung des Schrittes (F) des Anspruchs 1 gebracht werden.

10. Verfahren nach einem der Ansprüche 1 bis 9, bei welchem die Gegenstände Anordnungs- und/oder Haltevorrichtungen in einer Station einer Produktionslinie sind.

11. Verfahren nach einem der Ansprüche 1 bis 10, bei welchem das Netzwerk der Hilfsreferenzpunkte auf einer bewegbaren Vorrichtung erstellt wird und bei welchem die bewegbare Vorrichtung in eine Station in einer Produktionslinie vor der Durchführung der Schritte (E) und (F) des Anspruchs 1 bewegt wird.

12. Verfahren nach Anspruch 11, bei welchem die bewegbare Vorrichtung in jede einer Vielzahl von Stationen in einer Produktionslinie vor der Durchführung der Schritte (D), (E) und (F) des Anspruchs 1 in jeder der Stationen bewegt wird.

13. Verfahren nach einem der Ansprüche 1 bis 12, bei welchem die Gegenstände Ebenen, Linien, Löcher, Zylinder, Kugeln und/oder kombinierte Gegenstände wie Roboterarme oder andere industrielle Produktionsausrüstungselemente aufweisen.

14. System zum Bestimmen der Position und/oder der Orientierung einer Anzahl von Punkten oder Gegenständen relativ zueinander, aufweisend:

(A) mindestens zwei Kameras;
(B) Einrichtungen zum Erstellen eines Netzwerks von Hilfsreferenzpunkten;
(C) Einrichtungen zum Bestimmen der räumlichen Positionen einiger Punkte in dem Netzwerk relativ zueinander unter Verwendung von mindestens einer der Kameras, positioniert an vielfachen willkürlichen Orten, wobei mindestens eine Kamera Projektionen der Positionen der einigen Netzwerkpunkte bestimmt;
(D) Einrichtungen zum Positionieren einiger der Kameras, so dass sie mindestens drei Hilfsreferenzpunkte sehen können;
(E) Einrichtungen zum Bestimmen der Positionen und Orientierungen der einigen der Kameras unter Verwendung der räumlichen Positionen der Netzwerkpunkte, bestimmt mit den Einrichtungen (C); und
(F) Einrichtungen zum Bestimmen der Position und/oder der Orientierung einiger der Punkte oder Gegenstände relativ zueinander, auf der Basis der bestimmten Positionen und Orientierungen einiger der Kameras, wobei die Position und/oder Orientierung von mindestens einem der Punkte oder Gegenstände bestimmt wird durch

(i) ein Messfühlerinstrument in Kontakt mit dem Punkt oder mindestens einem Punkt auf dem Gegenstand, und
(ii) Einrichtungen zum Erhalten von Messdaten von dem Messfühlerinstrument unter Verwendung von mindestens zwei der Kameras.

15. System nach Anspruch 14, bei welchem das Netzwerk von Hilfsreferenzpunkten mindestens zwei Punkte mit einem bekannten gegenseitigen Trennabstand aufweist, der verwendet wird, um eine korrekte Längenskala zu bestimmen.

16. System nach Anspruch 15, bei welchem die mindestens zwei Punkte auf einem Bezugsstab positioniert sind.

17. System nach einem der Ansprüche 14 bis 16, bei welchem die Hilfsreferenzpunkte ausgewählt sind aus Lichtquellen, projizierten Lichtpunkten und beleuchteten Reflektoren oder Punkte sind, die von einem Messfühlerinstrument berührt werden können, auf welchen Lichtquellen oder Reflektoren angeordnet sind.

18. System nach Anspruch 17, bei welchem die Lichtquellen lichtemittierende Dioden sind.

19. System nach Anspruch 17 oder 18, bei welchem mindestens einige der Hilfsreferenzpunkte Lichtquellen sind.

20. System nach einem der Ansprüche 17 bis 19, bei welchem die Position von mindestens einem der Hilfsreferenzpunkte unter Verwendung des Messfühlerinstrumentes bestimmt wird.

21. System nach einem der Ansprüche 14 bis 20, bei welchem die Linsenverzeichnungen der Kameras auf der Grundlage der räumlichen Positionen der Hilfsreferenzpunkte bestimmt werden.

22. System nach einem der Ansprüche 14 bis 21, bei welchem das Netzwerk der Hilfsreferenzpunkte innerhalb eines bestimmten Volumens erstellt wird

und bei welchem die Gegenstände in dieses Volumen gebracht werden.

23. System nach einem der Ansprüche 14 bis 22, bei welchem die Gegenstände Anordnungs- und/oder Haltevorrichtungen in einer Station einer Produktionslinie sind.

24. System nach einem der Ansprüche 14 bis 23, bei welchem das Netzwerk der Hilfsreferenzpunkte auf einer bewegbaren Vorrichtung erstellt ist und bei welchem die bewegbare Vorrichtung in eine Station in einer Produktionslinie bewegt wird.

25. System nach Anspruch 24, bei welchem die bewegbare Vorrichtung in jede einer Vielzahl von Stationen in einer Produktionslinie bewegt wird.

26. System nach einem der Ansprüche 14 bis 25, bei welchem die Gegenstände Ebenen, Linien, Löcher, Zylinder, Kugeln und/oder kombinierte Gegenstände wie Roboterarme oder andere industrielle Produktionsausrüstungselemente aufweisen.

Revendications

1. Un procédé pour déterminer la position et/ou l'orientation d'un certain nombre de points ou d'objets les uns par rapport aux autres, le procédé comprenant les étapes consistant à :

   (A) disposer d'au moins deux caméras ;
   (B) établir un réseau de points de référence d'aide ;
   (C) déterminer les positions dans l'espace de certains points dans le réseau les uns par rapport aux autres en utilisant au moins l'une des caméras positionnées en des emplacements arbitraires multiples, ladite au moins une caméra déterminant des projections desdits certains points du réseau ;
   (D) positionner certaines des caméras de telle sorte qu'elles puissent voir au moins trois points de référence d'aide ;
   (E) déterminer les positions et orientations des certaines caméras en utilisant les positions spatiales des points de réseau déterminés à l'étape (C) ; et
   (F) déterminer la position et/ou l'orientation de certains des points ou objets les uns par rapport aux autres, sur la base des positions et orientations déterminées de certaines des caméras, en sorte que la position et/ou l'orientation d'au moins l'un des points ou objets soit déterminée en :

      (i) maintenant un outil de sondage en contact avec le point ou au moins un point sur l'objet, et
      (ii) obtenant des données de mesure de l'outil de sondage en utilisant au moins deux des caméras dont les positions ont été déterminées à l'étape (E).

2. Le procédé selon la revendication 1, où le réseau de points de référence d'aide comprend au moins deux points présentant une distance de séparation mutuelle connue utilisés pour déterminer une échelle de longueur correcte.

3. Le procédé selon la revendication 2, où les au moins deux points sont positionnés sur une barre de référence.

4. Le procédé selon l'une des revendications 1 à 3, où les points de référence d'aide sont choisis parmi des sources lumineuses, des spots lumineux projetés et des réflecteurs illuminés ou sont des points qui peuvent être touchés par un outil de sondage possédant des sources lumineuses ou des réflecteurs qui lui sont attachés.

5. Le procédé selon la revendication 4, où les sources lumineuses sont des diodes électroluminescentes.

6. Le procédé selon la revendication 4 ou 5, où au moins certains des points de référence d'aide sont des sources lumineuses.

7. Le procédé selon l'une des revendications 4 à 6, où la position d'au moins l'un des points de référence d'aide est déterminée en utilisant l'outil de sondage.

8. Le procédé selon l'une des revendications 1 à 7, où les distorsions de lentille des caméras sont déterminées sur la base des positions dans l'espace des points de référence d'aide.

9. Le procédé selon l'une des revendications 1 à 8, où le réseau des points de référence d'aide est établi au sein d'un certain volume et où le objets sont amenés au sein de ce volume avant exécution de l'étape (F) de la revendication 1.

10. Le procédé selon l'une des revendications 1 à 9, où les objets sont des dispositifs de positionnement et/ou de maintien dans un poste d'une chaîne de production.

11. Le procédé selon l'une des revendications 1 à 10, où le réseau de points de référence d'aide est établi sur un dispositif mobile et dans lequel le dispositif mobile est déplacé jusque dans un poste d'une chaîne de production avant exécution des étapes (E) et (F) de la revendication 1.

12. Le procédé selon la revendication 11, où le dispositif mobile est déplacé jusque dans chacun d'une pluralité de postes d'une chaîne de production avant exécution des étapes (D), (E) et (F) de la revendication 1 dans chacun des postes.

13. Le procédé selon l'une des revendications 1 à 12, où les objets comprennent des plans, des lignes, des trous, des cylindres, des sphères et/ou des objets combinés comme des bras de robot ou autre équipent de production industrielle.

14. Système pour déterminer la position et/ou l'orientation d'un certain nombre de points ou d'objets les uns par rapport aux autres, comprenant :

(A) au moins deux caméras ;
(B) des moyens pour établir un réseau de points de référence d'aide ;
(C) des moyens pour déterminer les positions dans l'espace de certains points dans le réseau les uns par rapport aux autres en utilisant au moins l'une des caméras positionnées en des emplacements arbitraires multiples, ladite au moins une caméra déterminant des projections desdits certains points du réseau ;
(D) des moyens positionnant certaines des caméras de telle sorte qu'elles puissent voir au moins trois points de référence d'aide ;
(E) des moyens pour déterminer les positions et orientations des certaines caméras en utilisant les positions spatiales des points de réseau déterminés par les moyens (C) ; et
(F) des moyens déterminant la position et/ou l'orientation de certains des points ou objets les uns par rapport aux autres, sur la base des positions et orientations déterminées de certaines des caméras, en sorte que la position et/ou l'orientation d'au moins l'un des points ou objets soit déterminée par :

(i) un outil de sondage en contact avec le point ou au moins un point sur l'objet, et
(ii) des moyens pour obtenir des données de mesure de l'outil de sondage en utilisant au moins deux des caméras.

15. Le système selon la revendication 14, où le réseau de points de référence d'aide comprend au moins deux points présentant une distance de séparation mutuelle connue utilisés pour déterminer une échelle de longueur correcte.

16. Le système selon la revendication 15, où les au moins deux points sont positionnés sur une barre de référence.

17. Le système selon l'une des revendications 14 à 16, où les points de référence d'aide sont choisis parmi des sources lumineuses, des spots lumineux projetés et des réflecteurs illuminés ou sont des points qui peuvent être touchés par un outil de sondage possédant des sources lumineuses ou des réflecteurs qui lui sont attachés.

18. Le système selon la revendication 17, où les sources lumineuses sont des diodes électroluminescentes.

19. Le système selon la revendication 17 ou 18, où au moins certains des points de référence d'aide sont des sources lumineuses.

20. Le système selon l'une des revendications 17 à 19, où la position d'au moins l'un des points de référence d'aide est déterminée en utilisant l'outil de sondage.

21. Le système selon l'une des revendications 14 à 20, où les distorsions de lentille des caméras sont déterminées sur la base des positions dans l'espace des points de référence d'aide.

22. Le système selon l'une des revendications 14 à 21, où le réseau des points de référence d'aide est établi au sein d'un certain volume et où le objets sont amenés au sein de ce volume.

23. Le système selon l'une des revendications 14 à 22, où les objets sont des dispositifs de positionnement et/ou de maintien dans un poste d'une chaîne de production.

24. Le système selon l'une des revendications 14 à 23, où le réseau de points de référence d'aide est établi sur un dispositif mobile et dans lequel le dispositif mobile est déplacé jusque dans un poste d'une chaîne de production.

25. Le système selon la revendication 24, où le dispositif mobile est déplacé jusque dans chacun d'une pluralité de postes d'une chaîne de production.

26. Le système selon l'une des revendications 1 à 25, où les objets comprennent des plans, des lignes, des trous, des cylindres, des sphères et/ou des objets combinés comme des bras de robot ou autre équipent de production industrielle

Fig. 1a. (Prior art)

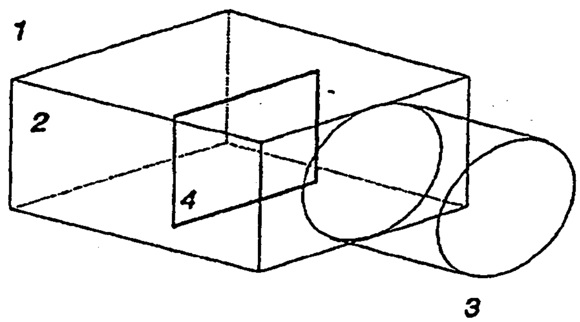

Fig. 1b. (Prior art)

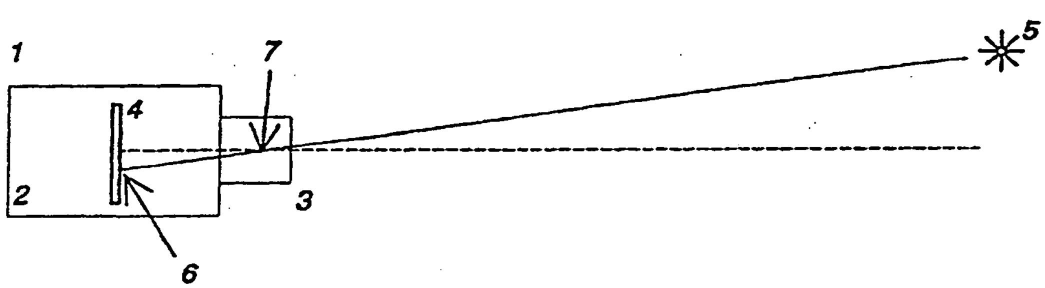

Fig. 2 (Prior art)

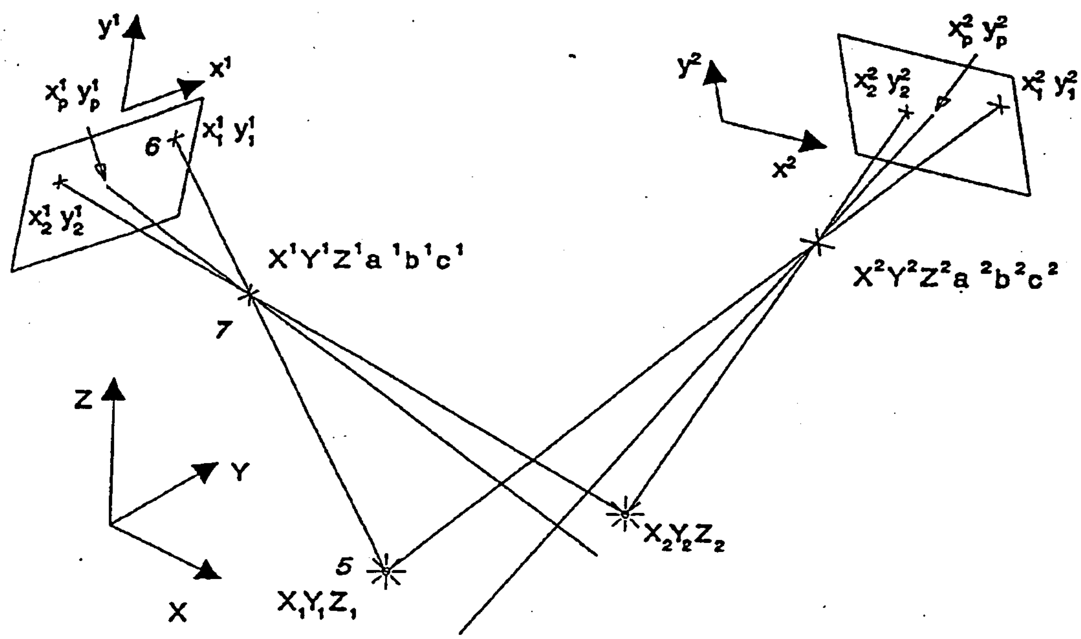

Fig. 3

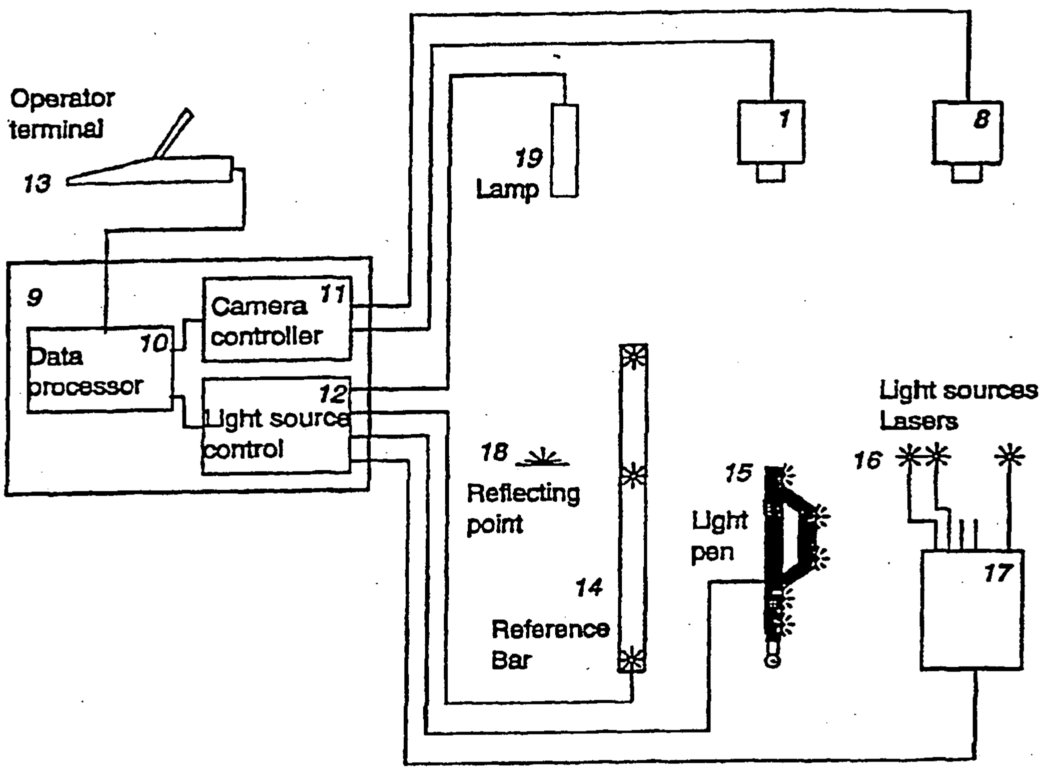
Operator terminal
13
9
Data processor
10
Camera controller
11
Light source control
12
19
Lamp
1
8
18
Reflecting point
14
Reference Bar
15
Light pen
Light sources Lasers
16
17

Fig. 4a

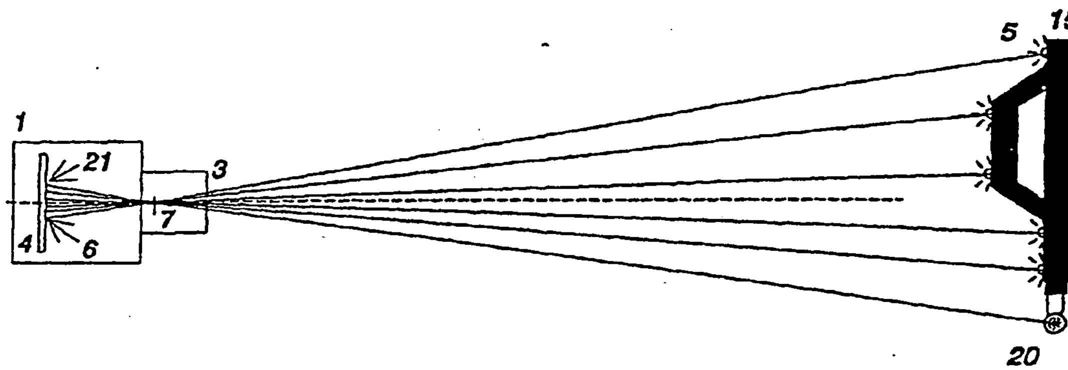

Fig. 4b

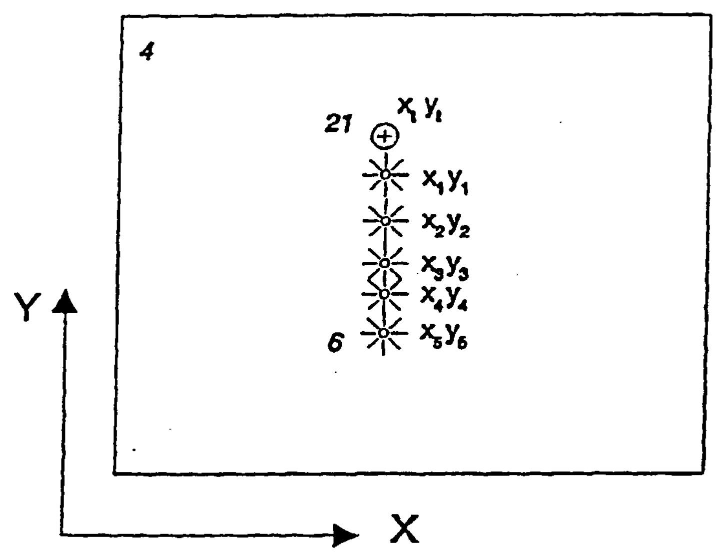

Fig. 5

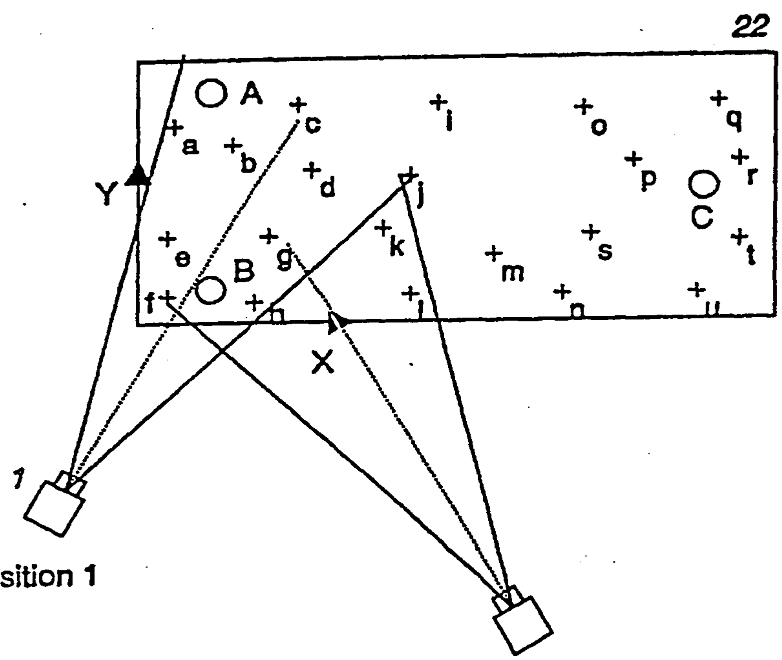

Fig. 6

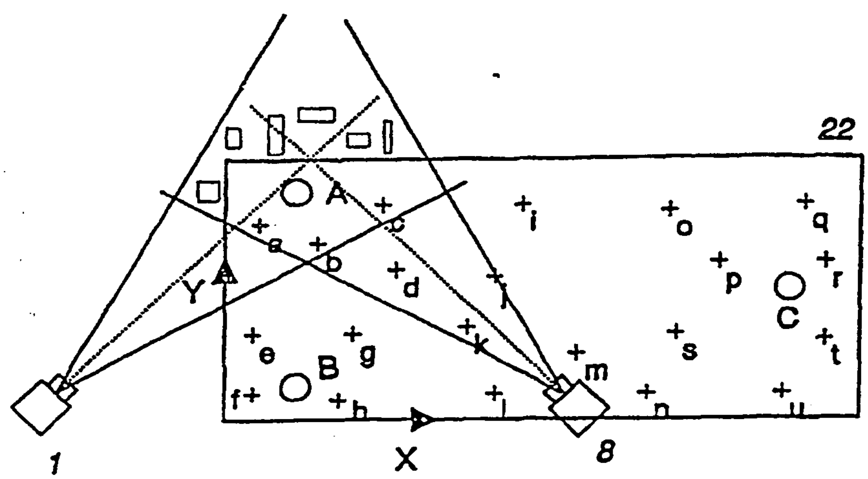

Fig. 7a

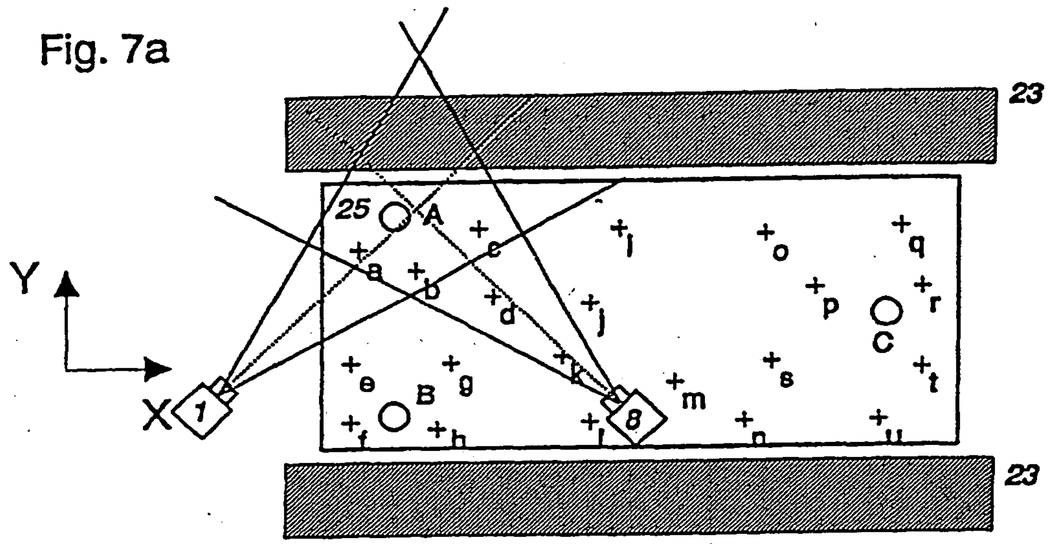

Fig. 7b

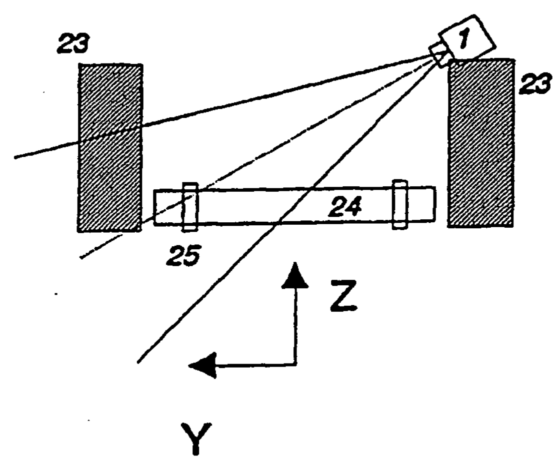

Fig. 8a

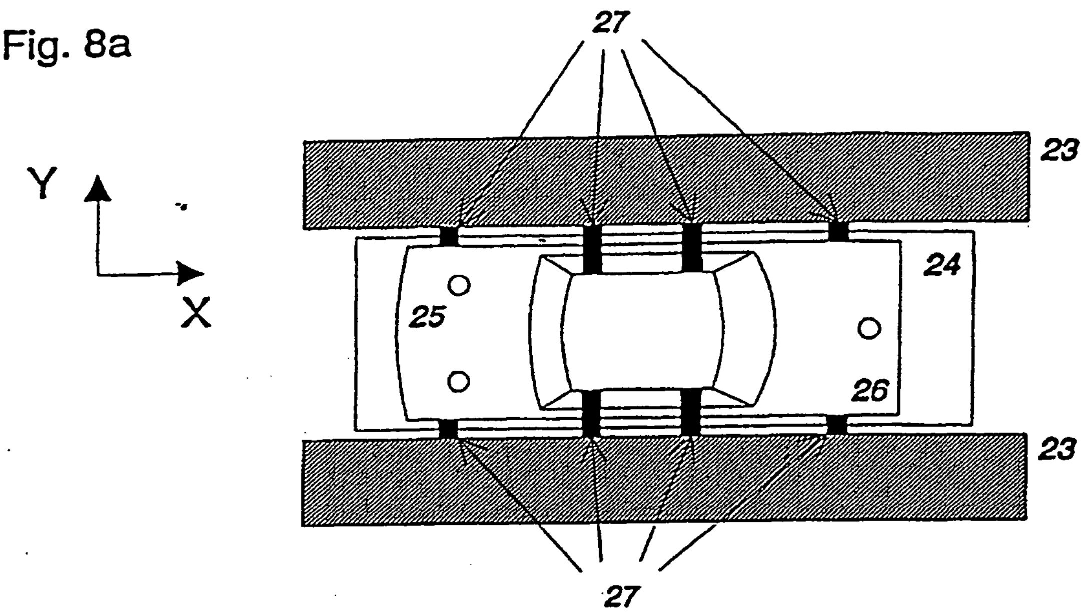

Fig. 8b

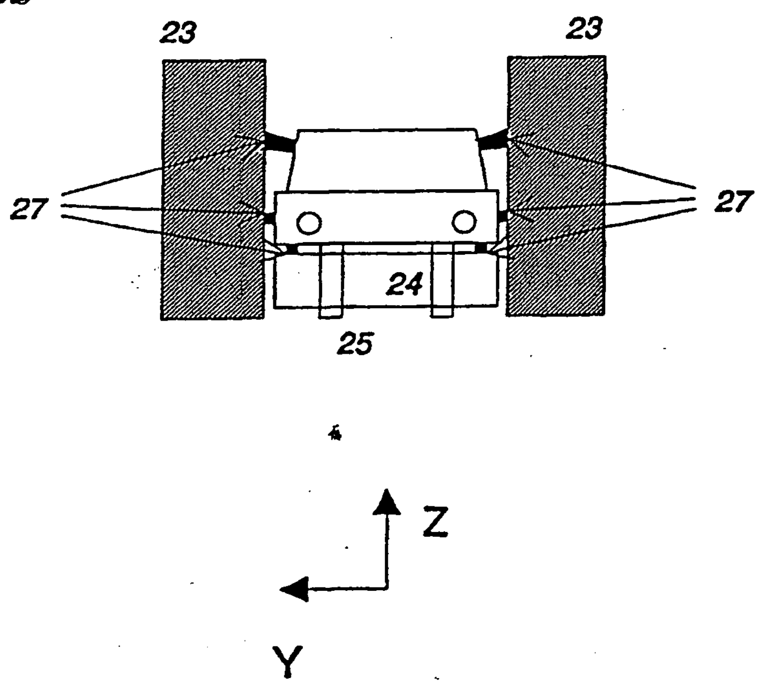

Fig. 9

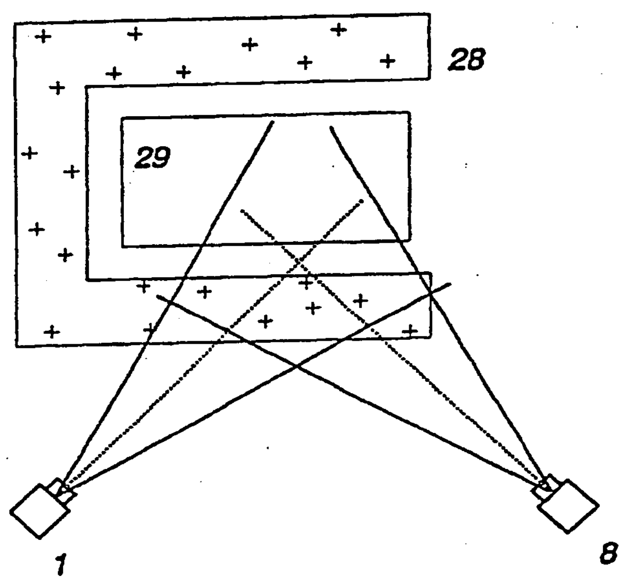

Fig. 10